Detector Summary

S.Klimenko

University of Florida,

for the MC detector working group

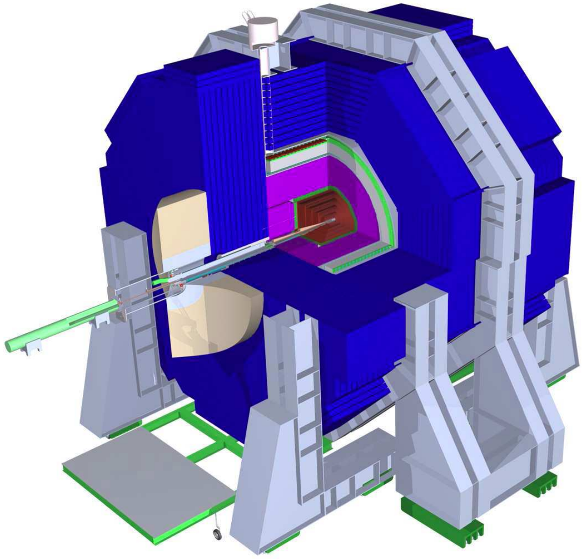
(view from outside)

many thanks to speakers for interesting talks.

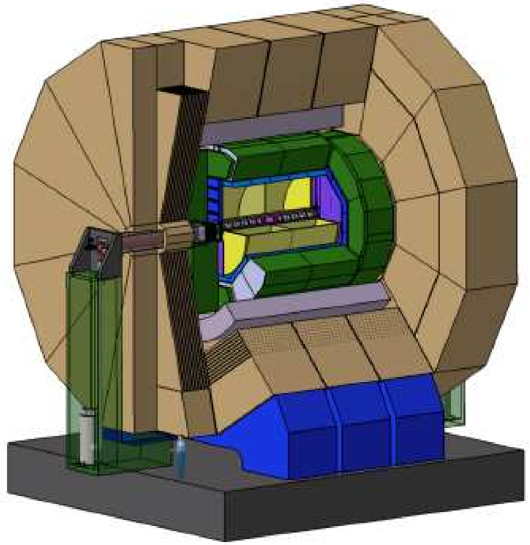
ILC benchmark reference

- Three ILC detectors (LOI submitted in March 2009) form a solid reference and benchmark for the detector and physics performance at a lepton collider in the energy range of 500 GeV–1 TeV

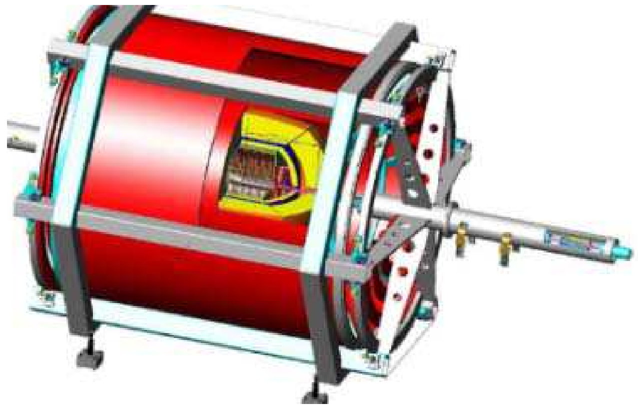
SiD



ILD



4th



need some adjustments for CLIC, but no big conceptual difference

Detector performance parameters

- **Heavy flavor identification**
- **Technology and cost**
- **Higgs recoil mass**
- $\mu^+\mu^- \rightarrow WW..\ ZZ...\ tt..\ ZH...$
- **jet reconstruction: W/Z, etc. (PFA, Compensated)**
- **good particle ID**
- **~4π solid angle:**
  - **instrumented down to 5mrad**

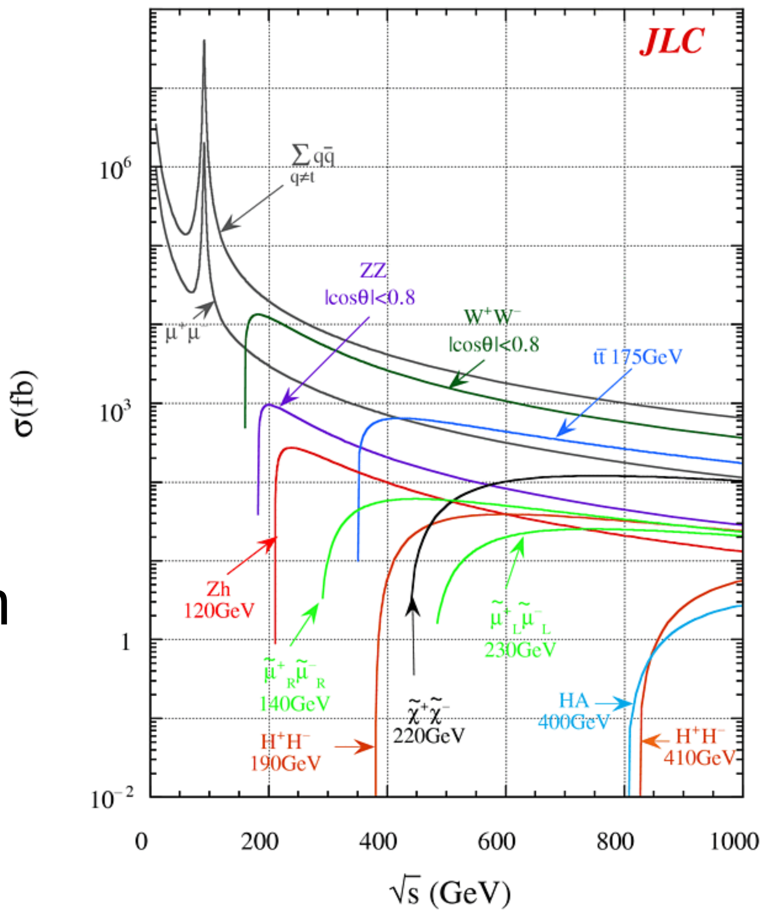
Detector	ILC	CLIC
Vertexing	$5\ \mu\mathrm{m} \oplus \frac{10\ \mu\mathrm{m}}{\mathrm{p}\ \sin^{3/2}\vartheta}$	$15\ \mu\mathrm{m} \oplus \frac{35\ \mu\mathrm{m}}{\mathrm{p}\ \sin^{3/2}\vartheta}$
Solenoidal Field	$\mathrm{B} = 3\text{-}5\ \mathrm{T}$	$\mathrm{B} = 4\ \mathrm{T}$
Tracking	$\frac{\delta \mathrm{p_T}}{\mathrm{p_T^2}} = 5 \cdot 10^{-5}$	$\frac{\delta \mathrm{p_T}}{\mathrm{p_T^2}} = 5 \cdot 10^{-5}$
EM Calorimeter	$\frac{\sigma_\mathrm{E}}{\mathrm{E}} = \frac{0.10}{\sqrt{\mathrm{E}}} \oplus 0.01$	$\frac{\sigma_\mathrm{E}}{\mathrm{E}} = \frac{0.10}{\sqrt{\mathrm{E}}} \oplus 0.01$
HAD Calorimeter	$\frac{\sigma_\mathrm{E}}{\mathrm{E}} = \frac{0.50}{\sqrt{\mathrm{E}}} \oplus 0.04$	$\frac{\sigma_\mathrm{E}}{\mathrm{E}} = \frac{0.40}{\sqrt{\mathrm{E}}} \oplus 0.04$
E-Flow	$\frac{\sigma(\mathrm{E_{jet}})}{\mathrm{E_{jet}}} = 0.03$	$\frac{\sigma(\mathrm{E_{jet}})}{\mathrm{E_{jet}}} = 0.03$

talks by M.Demarteau, A.Seryi, J.Hauptman, H.Yamamoto

Basic Considerations

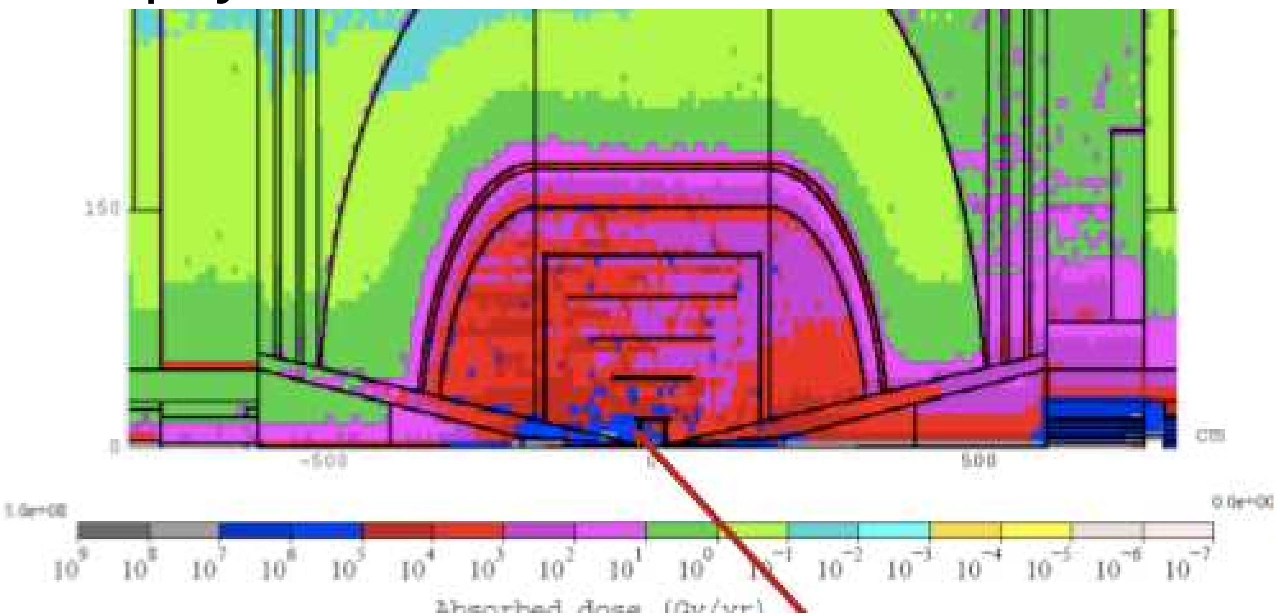
- μμ collision rate is very low: at ~1pb cross section and expected luminosity of 10^{34} the rate is well below 1Hz
- no detector radiation issues from collisions, some issues with MB
- No apparent triggering issues – just write down all collisions!
- Due to precision physics detector specifications are demanding however no immediate issues with designing detectors based on existing/developing technologies
- **BUT…**

uncertainty in physics landscape more important for machines than detectors



MC machine detector interface

- a big issue is large background from muon decays
  - can be simulated reasonably well (N.Mokhov et al)
  - affects detector design and specifications
  - possible loss of acceptance
  - expect larger systematic errors → affects precision physics



many questions how background affects detectors.

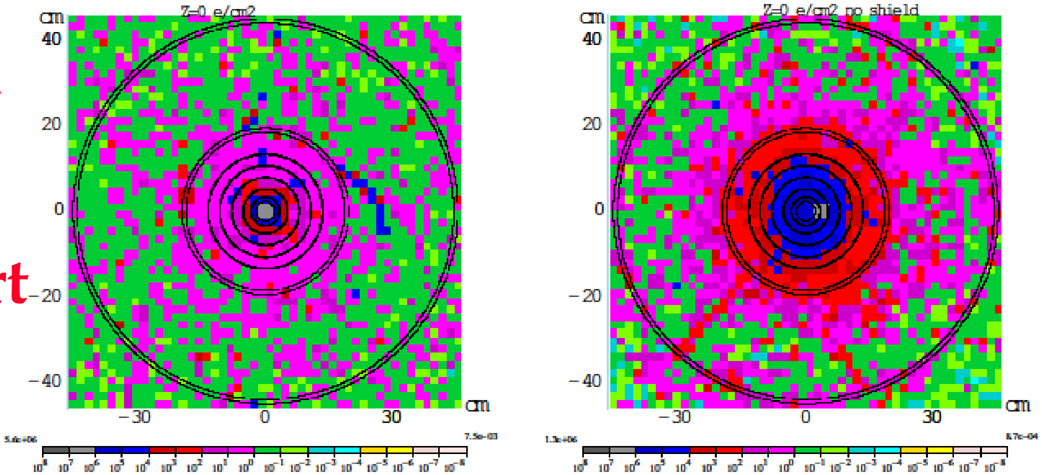
the background may significantly affect physics reach

Detector-MDI joint meeting

- Discussion of the “ugly” shielding cones
  - Recent background calculations are presented by (V.Alexahin and S.Striganov)

Results with and w/o shielding, electrons

-in principle cones work,
-performance impact
to be quantified
-joint MDI-detector effort

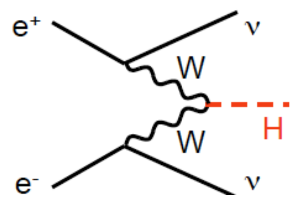


- 50-T solenoid
  - keep decay electrons (3mm gyro radius) inside beam pipe
  - preliminary ranking somewhere between “tough” and “crazy” – too much intervention into the machine lattice (Y.Alexahin)

Integration with physics

- need clear physics goals for MC
- quantify impact of the background on the MC physics potential

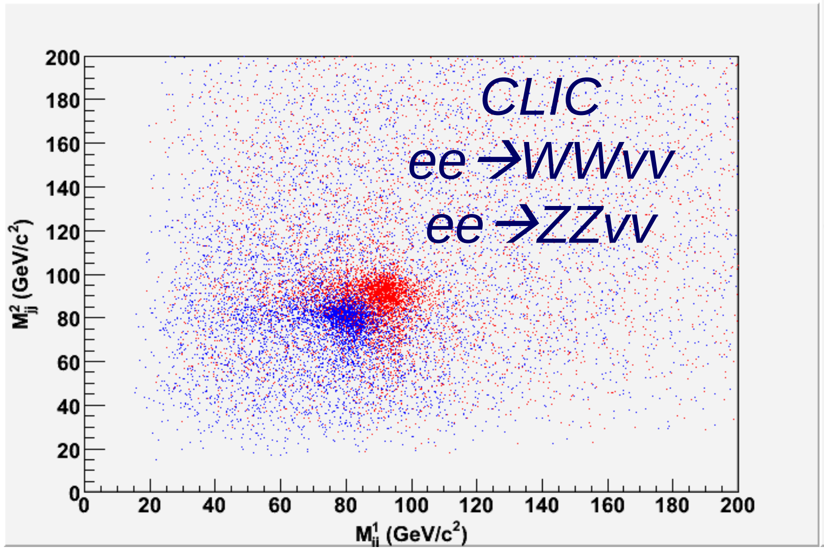
  - for example: t-channel is increasingly important with energy $\sigma \sim log(s)$, forward region – how is it affected?

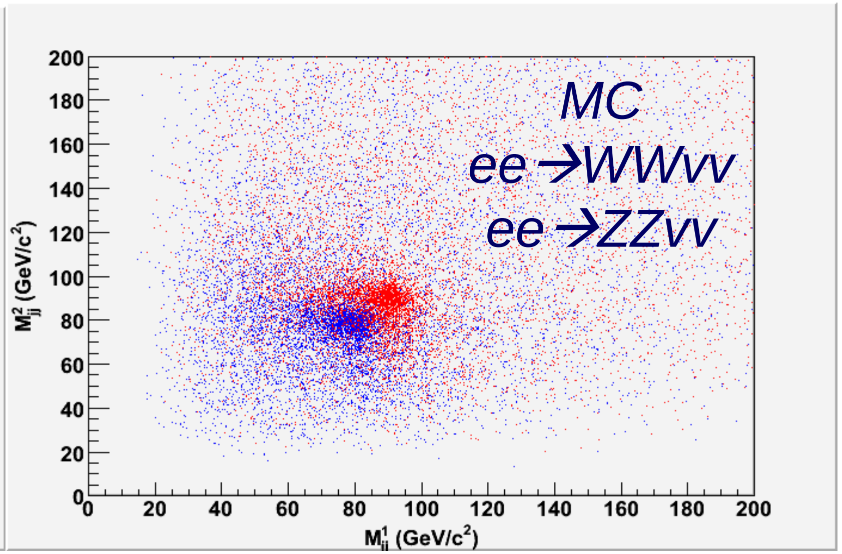


- quantify impact of the MC background on the detector performance and technical design specifications (TDS)
- need a set of benchmark physics processes to estimate detector performance and establish TDS

W/Z Separation (Anna Mazzacane)

- an important benchmark for ILC
- simulation using 4th detector (with the W cone) and ILCroot
  - will include background soon
- A good example of a benchmark process to quantify detector perfomance → we need more benchmarks from physics WG!





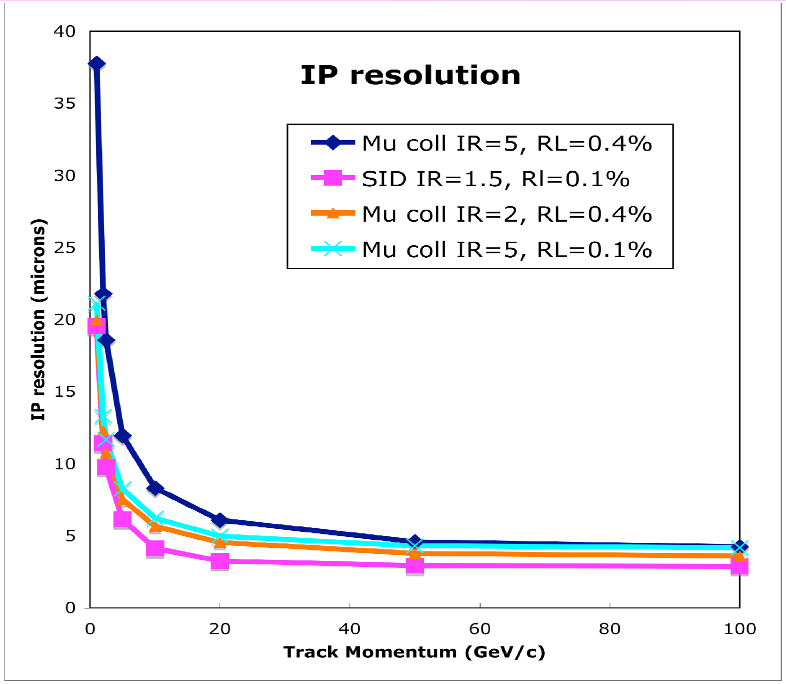
Detector R&D

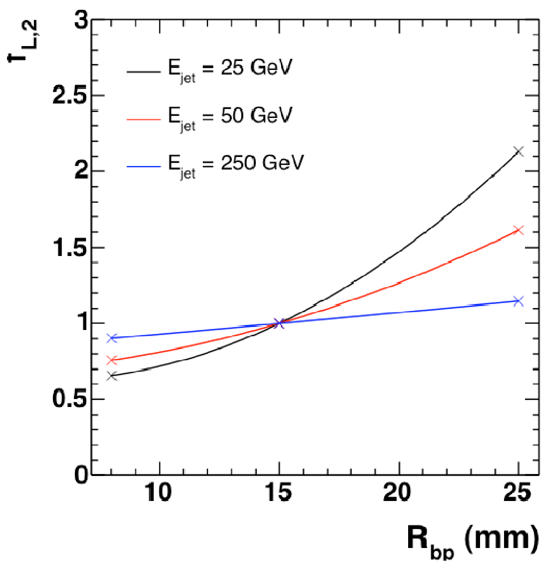
- Well established effort for ILC and CLIC
- What is the MC detector place in this picture?
  - horizontal vs dedicated R&D
  - Should ILC/CLIC people devote some time to MC?
  - Should MC people just join existing R&D program?
- Answer depends on how exciting is MC physics
  - need a clear physics case – H.Yamamoto: “detector people need to be educated about MC physics”
- Answer also depends on how serious is the MC background problem
  - C.Gato: “MC will benefit from a dedicated R&D (at least at the initial stage)”
- MC integration and coherent effort on the lepton collider detector R&D is important.

Vertex Detector (Ron Lipton)

most likely..

- cooled below 0 deg C
  - Increase RL
- larger radius
  - resolution degradation
- may be x 2 worse
- loss of forward region due to collimation “nose”?
- too early for real conclusions but it could be that excellent tracking and vertexing can be retained with reasonable effective luminosity loss



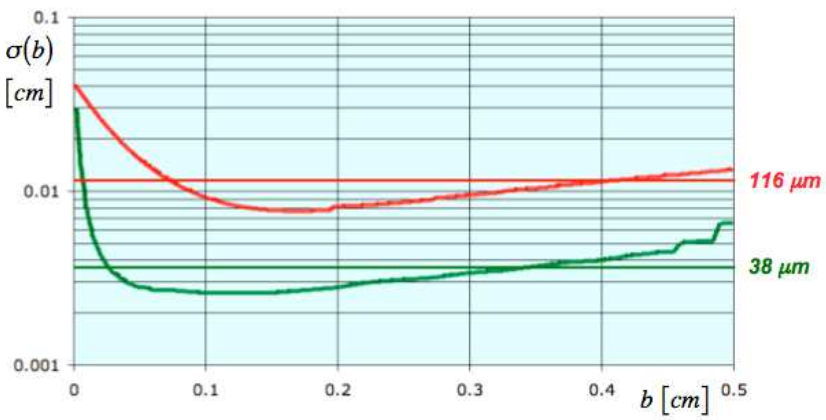


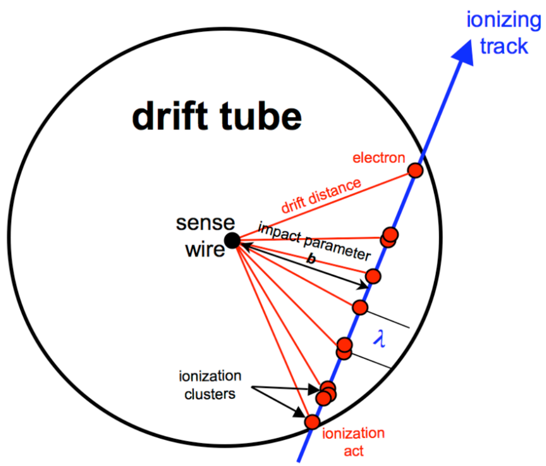
Luminosity factor

(2 jets) Hillert

Tracking detector options (F. Grancagnolo)

- TPC (may not work at high bkgd rate)
- Si tracker (many options are available)
  - expect much better technology in 10 years
- Low density He/Iso tracker with cluster counting
  - “more” transparent to background however it can be an issue at small R



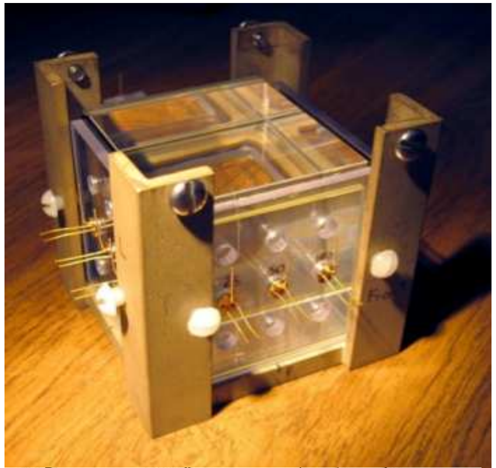


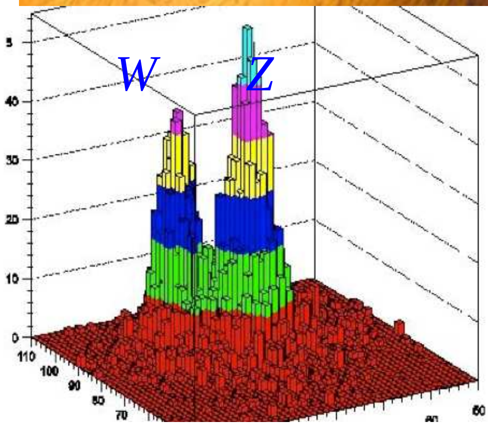
- Hybrid Si (inner) and gas (outer) tracker (?)

Dual-readout calorimetry

J.Hauptman
V.D. Benedetto
H.Wenzel

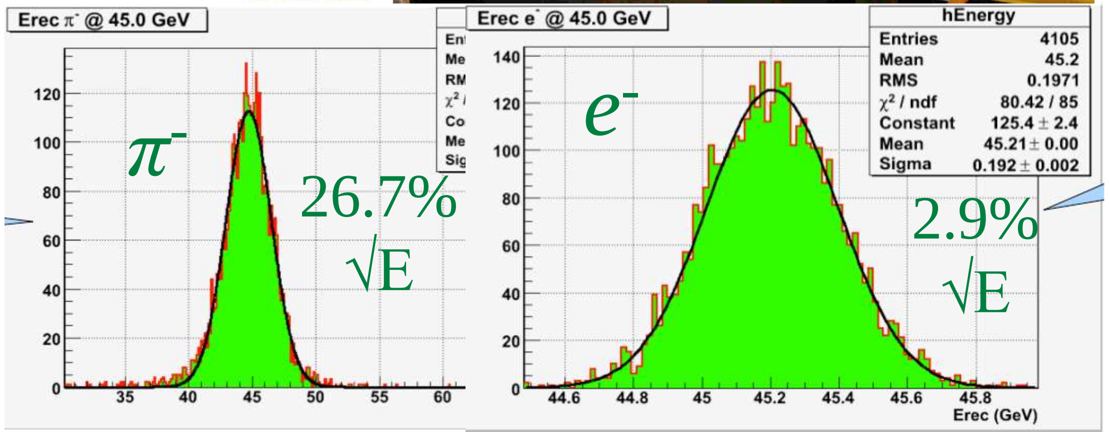
First all-crystal dual-readout test module with SiPMs



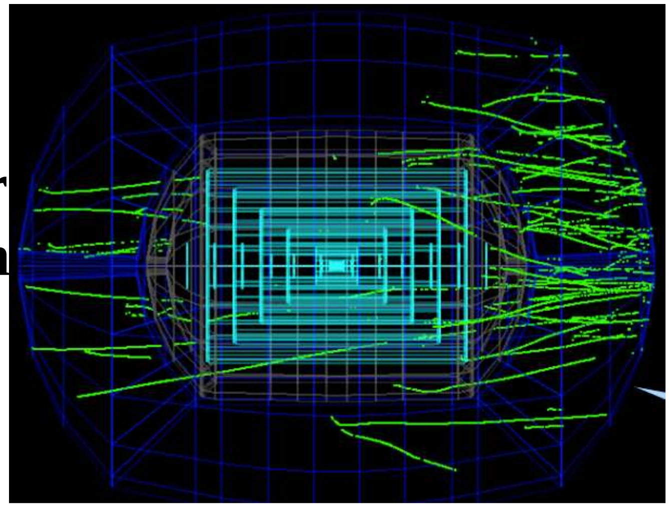


DREAM test beam data and 4th calibration results

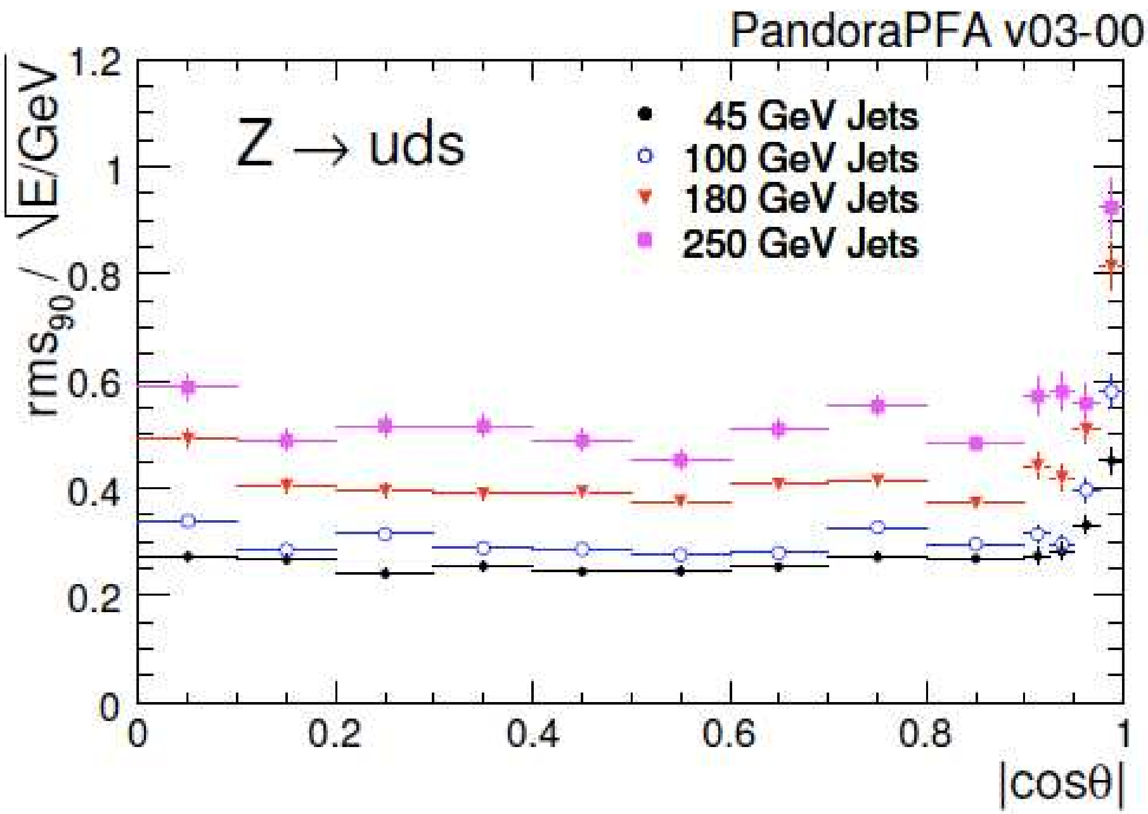
e, μ, π
20-300 GeV



Muon Collider muons into 4th detector



PFA Calorimetry



Achieved at Ejet up to ~100 GeV

from Hitoshi Yamamoto talk:
'Extremely promising, but simulation alone cannot be trusted.'

Simulation Tools

- Stephen Mrenna - MC4MC
  - tools to generate the Standard Model “cocktail” at multi-TeV MC
- Corrado Gato – ILCroot
  - A simulation framework combining a zoo of available simulation tools: GIANT, Fluka, Event generators, HPSS, etc
- Nikolai Mokhov – MARS
  - can be integrated into detector simulation
- Norman Graf – LCIO
  - common simulation format/IO for ILC
- Pere Mato – Simulation Frameworks

an arsenal of tools

integration, integration, integration

Summary

- Significant detector R&D in the scope of ILC and CLIC – a great reference point for MC
- An arsenal of tools for combined simulation of machine, detector and physics.
- Integration with machine detector interface
  - need smart ideas and a lot of work to mitigate background
  - expect a significant impact on detector design
- Integration with physics
  - need a clear physics case
  - quantify impact of the machine background on the MC physics
  - need a set of benchmark physics processes to estimate detector performance and establish technical design specifications
- Detector R&D
  - Innovative detector concepts are available/developing, expect more in the next 10 years →keep detector diversity/options open
  - "horizontal" vs dedicated R&D → integration of MC detector into coherent R&D program